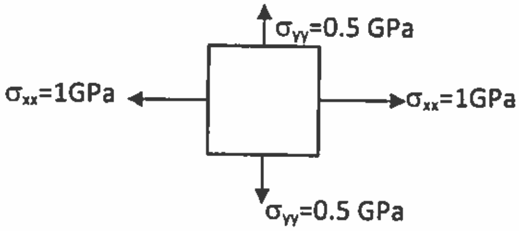
PLEASE NOTE: Answer all 3 problems.

Problem #1

A thin plate, shown in the figure, is subjected to biaxial stress field of σ_{xx}=1GPa and σ_{yy}=0.5 GPa.



1. Calculate the strains in the x, y directions if the plate is made of steel
2. Calculate the strains in the x, y directions if the plate is made of 0° unidirectional 60 vol% carbon fiber reinforced epoxy composite and the fibers are oriented in the x-direction
3. Calculate the strains in the 1,2 directions (1 direction is parallel to the fiber axis, 2 direction in normal to the fiber axis but in-plane)if the plate is made of a 45° unidirectional 60 vol% carbon fiber reinforced epoxy composite
4. Show in a simple 2-D schematic how the plate will deform as a result of the applied stress field for each of the three cases i.e, steel plate, 0° unidirectional and 45° unidirectional carbon fiber reinforced epoxy composites
5. What is the definition of
   a) an isotropic material
   b) orthotropic material
   c) anisotropic

List and justify your assumptions

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Material	Modulus (GPa)	Poisson's ratio
steel	207	0.33
epoxy	3.6	0.35
fiber	220	0.2

G_{12}=3.254 GPa

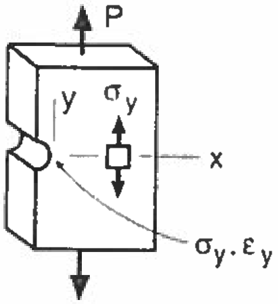
ν_{12} calculated using the rule of mixtures

$\nu_{21}=\nu_{12}\, E_{22}/E_{11}$, where E_{11} and E_{22} are the longitudinal and transverse modulus of the plate

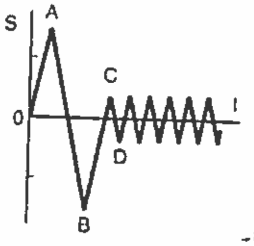
V_f = 60% (volume fraction of the fibers)

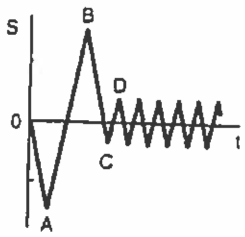
Problem # 2:

1) Consider the notched member shown below. Assume it is loaded sufficiently for local yielding to occur, and then completely unloaded (P = 0). For this loading scenario:
    a. plot a schematic of the nominal stress, S (S = P/A with A being the gross cross-section area) as a function of local strain at the notch root, ε_y;
    b. plot a schematic of the local stress at the notch root, σ_y, versus ε_y;
    c. discuss how these plots (a and b) could be obtained in a more quantitative manner;
    d. Upon unloading (P = 0), plot a schematic of the normal stress, σ_y, as a function of distance *x* from the notch root.



2) Consider a similar notched member (see image below) for which two different load histories are applied (see left and right plots of nominal stress, S, versus time).
    a. For each load history, plot a schematic of the local stress versus local strain at the notch root (assume the first cycle promotes significant plastic deformation at the notch).
    b. Which load history should result in a longer fatigue life and why (assume that the low amplitude cycling continues until failure of the component)?
    c. How would you estimate the fatigue life for this notched member for each load configuration? List your main assumptions.





Problem #3

Consider a 6-bar truss structure as shown in Figure 1. All the bars in the truss have the same cross-sectional area of A. Bars AB and CD are made of linear elastic materials, which are characterized by Young's moduli E_1 and E_2 and coefficients of thermal expansion α_1 and α_2. All the other bars are considered to be rigid with zero coefficient of thermal expansion. The structure is initially stress-free.

(a) Determine the stress developed in each bar due to a small, uniform temperature increase ΔT throughout the entire structure.

(b) How would your answer to (a) change if the structure is simultaneously subjected to the above thermal loading and a pair of compressive forces of magnitude F on joints A and B?

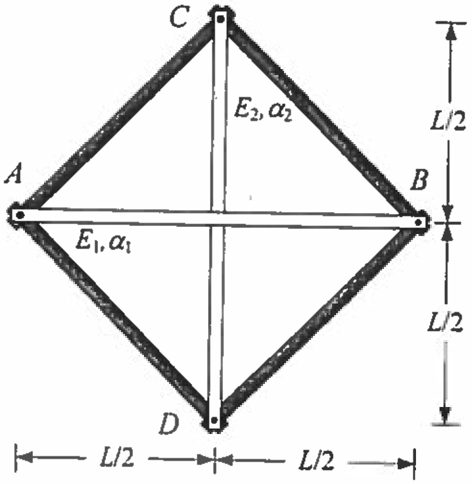


Figure 1